Candidate style answers

Statistical problem solving

High banded responses

Introduction

This resource has been produced by a senior member of the Core Maths examining team to offer teachers an insight into how the assessment objectives are applied. It has taken questions from the sample question paper and used them to illustrate how the questions might be answered and provide some commentary on what factors contribute to overall levels.

As these responses have not been through full moderation, they are banded to give an indication of the level of each response. Please note that this resource is provided for advice and guidance only and does not in any way constitute an indication of grade boundaries or endorsed answers.

The sample assessment material for these answers and commentary can be found on Teach Cambridge.

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(i) Show that the results from parts **(a)** and **(b)** and the modelling assumptions lead to the conclusion that the birds will reduce in numbers.

[3]

(ii) Give **two** comments about whether there is good evidence for the biologist to ask farmers to stop using insecticides near the wood.

[2]

Sample answer for question 1

(a) $5 + 1 + 1 + 2 + 3 = 12$

(b) The number of fledglings is 0 + 2 + 3 + 8 + 15 = 28

(c) (i) At start, 12 females

New birds, $\frac{1}{2}(2 + 3 + 8 + 15)$ are females = 14

Only 25% of these will survive predators so 25% of 14 = 3.5 breeding females.

3.5 × 3 years gives 10.5 new breeding females.

This is not enough to replace the 12 females at the start so the population will decline.

(ii) There may be something peculiar about that year; the farmer may need evidence from more than one year.

It may not be the pesticides that are to blame something else may have caused the problem.

Commentary on the answer

a) The frequencies are added correctly to show that there are 12 females.

b) The products of fledglings per female and number of females are added correctly to find the right number of fledglings.

c) (i) This answer has correctly used the information about birds lost to predators and has concentrated on the number of female birds to decide whether replacement takes place. It has also made correct use of the information that a female breeds three times to calculate the number of new females that will result.

d) (ii) This answer has two correct distinct comments; the realisation that other factors could be the cause and that there is no evidence that the birds are eating insects from the fields with pesticide.

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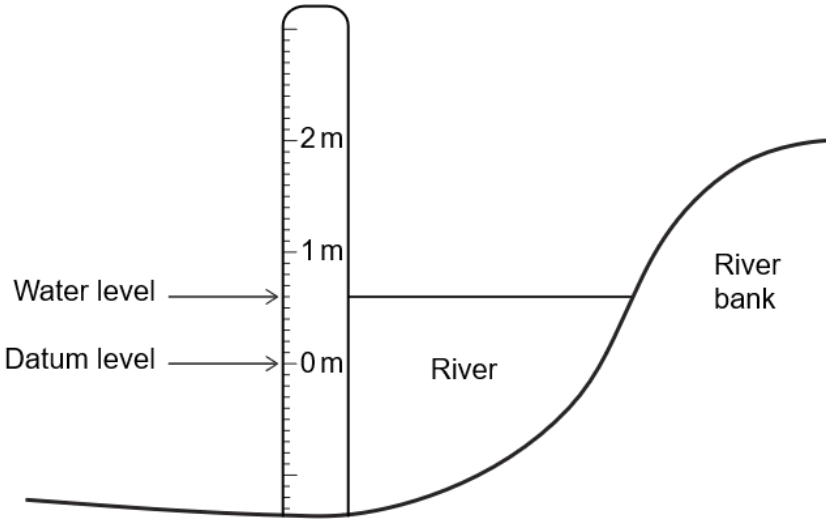
Question 2 (a)

A river flows through a town. If the height of the water level is more than 2 metres above a given datum level, the town will flood.



The cost of house insurance in this town increases.

The insurance companies say that this is because the risk of flooding is high.

The residents of the town decide to investigate the situation.

They want to be able to either:

- prove that the insurance companies are **not** correct or
- claim funding for flood defences.

The town's data records give the greatest height of the water above the datum level each year for the last 120 years.

The mean of these heights is 0.61 m.

The standard deviation is 0.48 m.

One of the residents uses the Normal distribution to model this situation.

(a) Use the Normal model to find the probability of the town flooding.

[3]

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Sample answer for question 2 (a)

(a) Level ~ $N(0.61, 0.48^2)$

$$z(2) = \frac{2 - 0.61}{0.48} = 2.895833$$

$$P(Z \leq 2.8985) = 0.9981$$

So, probability of the town flooding is $1 - 0.9981 = 0.0019$

Commentary on the answer

This answer has used the information that flooding occurs when the water level rises above 2 metres and has made correct use of the Normal distribution to find the probability of this.

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Question 2 (b)

(b) Use your answer to part **(a)** to determine if the statement below is **true** or **false**.

'The flood risk can be described as a once in 500 years event.'

Tick (ü) **one** box.

True ☐

False ☐

Show your reasoning.

[2]

Sample answer for question 2 (b)

(b) 0.0019 ≈ $\frac{20}{10000} = \frac{2}{1000} = \frac{1}{500}$ so about once in 500 years

Commentary on the answer

This answer correctly shows how the probability found in part (a) relates to once in 500 years.

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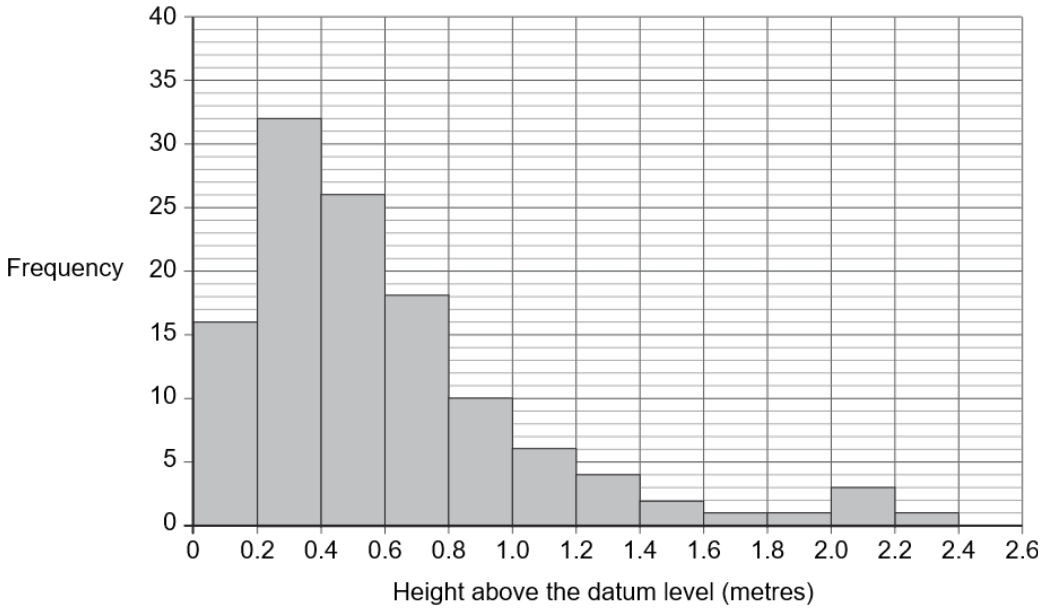
Question 2 (c)

(c) Another resident uses the data records to draw this frequency chart.
The chart shows the greatest heights above the datum level from the last 120 years.



(i) Use the frequency chart to find the probability of a flood.

[2]

(ii) Taking this new information into account, comment on the work the residents have done so far and advise them on what they should do.

[3]

Sample answer for question 2 (c)

(c) (i) $\frac{4}{120} = \frac{1}{30}$

(ii) The new information shows 4 floods in 120 years which suggests that the model may need to be refined. I would use the data from more recent years only because there may have been changes in the surrounding area which has made flooding more likely, or changes in weather patterns over time. The data in the diagram is not symmetrical like the normal distribution, it is skewed.

Commentary on the answer

(c) (i) The information in the frequency chart is used correctly to find the right probability.

(c) (ii) This answer has correctly identified that the model may need to be refined and has also correctly suggested that more recent information would be best to use, with a reason.

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The skewness in the diagram is a strong indicator that a Normal model is not appropriate and this has been identified.

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Question 3 (a) to (c)

A psychology student has devised a test for how easily people do what they are told.

The test places each person in one of three categories: C, D and N.

C - People who will always do what they are told without questioning it.

D - People who will only do what they are told without question if they respect the person asking them.

N - People who will never do what they are told without first questioning it.

The student used the test in an experiment to find out if there are differences in how easily people who support six different rugby teams do as they are told.

He tried the test out on groups of rugby supporters attending rugby matches between the six different teams.

The student stood in the street outside rugby matches and gave out vouchers to participants to get them to take part in his test.

The table shows their results.

Team supported	**C**	**D**	**N**
England	0	0	20
France	6	8	6
Ireland	5	7	8
Italy	6	8	6
Scotland	3	11	6
Wales	10	5	5

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(a) Which sampling method did the student use?

Tick (ü) **one** box.

Opportunity	☐
Self-selected	☐
Cluster	☐
Simple random	☐
Quota	☐
Stratified	☐

[1]

(b) The information for England is an outlier.
Explain what this means.

[1]

(c) The student carries out a χ^2 test using the data.
State the null and alternative hypotheses for a χ^2 test.

[1]

Sample answer for question 3 (a) to (c)

(a) Opportunity sampling

(b) It is not consistent with the rest of the data.

(c) H_0: The proportions in each category are independent of nationality

H_1: The proportions in each category are not independent of nationality.

Commentary on the answer

(a) This answer best describes the sampling method the student used.

(b) This answer sufficiently explains the term “outlier”.

(c) This answer has correct statements for the null and alternative hypotheses.

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Question 3 (d) to (g)

(d) **Table 3.1** shows the expected frequencies for the data with the outlier excluded.

Complete **Table 3.1**.

Table 3.1

Expected frequencies	**C**	**D**	**N**	**TOTAL**
France				
Ireland				
Italy			6.2	**20**
Scotland				**20**
Wales				
TOTAL	**30**	**39**		**100**

[2]

(e) **Table 3.2** shows the contributions to the test statistic for a χ^2 test.

Calculate the test statistic for a χ^2 test by first completing **Table 3.2**.

Table 3.2

Contributions to χ^2	**C**	**D**	**N**
France	0		0.006
Ireland	0.167	0.082	0.523
Italy	0		0.006
Scotland	1.5	1.313	0.006
Wales	2.667		0.232

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[2]

(f) Carry out the χ^2 test.

Use a 5% significance level.

[4]

(g) Make **two** comments on the conduct of the experiment.

[2]

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Sample answer for Question 3 (d) to (g)

(d) $\frac{30 \times 20}{100} = 6$

$\frac{39 \times 20}{100} = 7.8$

$\frac{31 \times 20}{100} = 6.2$

Expected frequencies	C	D	N	TOTAL
France	6	7.8	6.2	**20**
Ireland	6	7.8	6.2	**20**
Italy	6	7.8	6.2	**20**
Scotland	6	7.8	6.2	**20**
Wales	6	7.8	6.2	**20**
TOTAL	**30**	**39**	**31**	**100**

(e) $\frac{(8 - 7.8)^2}{7.8} = 0.005128...$

$\frac{(5 - 7.8)^2}{7.8} = 1.005128...$

Contributions to χ^2	C	D	N
France	0	0.005	0.006
Ireland	0.167	0.082	0.523
Italy	0	0.005	0.006
Scotland	1.5	1.313	0.006
Wales	2.667	1.005	0.232

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$\chi^2 = 7.52$

(f) Degrees of freedom = $2 \times 4 = 8$

5% significance from the chi-squared table for 8df = 15.51

As $7.52 < 15.51$, there is insufficient evidence to reject H_0

There is insufficient evidence that there are differences between the nationalities.

(g) The sample is not representative of the nationalities; rugby fans are more likely to be male, plus as the sample was taken outside the stadium some of the fans may have answered as a group rather than individually.

Commentary on the answer

(d) & (e) The correct values are calculated.

(f) There is a correct completion of a chi-squared test at 5% significance level. The conclusion states that there is insufficient evidence to accept the alternative hypothesis and it has been related back to the original context.

(g) This answer gives two correct comments, as required. It recognises that the sample may not be representative and that the surroundings are not ideal for this experiment.

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Question 4

Use the **pre-release data** to answer the questions. A hard copy of the **pre-release data** is provided.

(a) The sum of the figures in the column headed "Population" in the pre-release data gives a total of 7 174 654 290.

Give **two** reasons why this is **not** the current world population.

[2]

(b) Is the statement below **true** or **false**?

'Over a quarter of the world's population lives in just two countries.'

Tick (ü) **one** box.

Justify your answer.

True ☐

False ☐

[3]

(c) (i) Calculate the number of births per year in Ghana.

[2]

(ii) Compare the number of births per year in Ghana to the number of births per year in the UK.

[2]

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Sample answer for question 4

(a) The figures are given to the nearest person but most population figures are not given as accurately so the data may not be as accurate as it claims to be.
The population will have changed since the data were collected.

(b) $\frac{1}{4}$ of 7 174 654 290 ≈ 1.79 bn
China and India make 1 236 344 631 + 1 355 692 576 = 2 592 037 207
This is more than $\frac{1}{4}$ of the population.

(c) (i) Ghana: 25 758 108 × 31.40 ÷ 1000 = 808 804

(ii) UK : 63 742 977 × 12.22 ÷ 1000 = 778 939
So, the numbers are very close.

Commentary on the answer

(a) This answer is correct and gives two reasons – the possibility of change and the unreasonable level of accuracy given.

(b) This answer correctly works out one quarter of the world's population and identifies that China and India together are over one quarter of the world's population.

(c) This answer works out and compares the required quantities (the number of births per year) in both countries and gives a conclusion related to the answer.

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Question 5

In the **pre-release data**, GDP per capita is given by country.

(a) Explain how you would use a spreadsheet containing the pre-release data to calculate an estimate of the GDP per capita for the whole world.

[3]

(b) Explain what this figure represents.

[1]

(c) Demonstrate your method using data from Japan, Nigeria and Sri Lanka.

You can use the table provided to help you.

Country	**Sub region**				
Japan	East & South East Asia				
Nigeria	Africa (Sub-Saharan)				
Sri Lanka	South Asia				

[4]

Sample answer for question 5

(a) Add an extra column for “Population × GDP” then sum it and divide by the population of the world.

(b) The figure would be what each person would get if the entire world’s wealth was shared out.

A	B	C	D	
Country	**Population**	**GDP per capita**		
Japan	127 103 388	37 100	4.7155×10^{12}	
Nigeria	177 155 754	2800	4.960×10^{11}	
Sri Lanka	21 866 445	6500	1.421×10^{11}	
	326 125 587		5.3537×10^{12}	

(c)

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$\text{GDP} = 5.3537 \times 10^{12} \div 326\,125\,587 = \$16\,416$

Commentary on the answer

(a) & (b) The explanation of the method at the start of this answer is correct, as is the interpretation of what the answer represents.

(c) The answer goes on to show a correct method for GDP per capita for these three countries together.

Question 6 (a) and (b)

A student thinks that valuable insights can be obtained from the pre-release data.

In order to carry out a pilot investigation the student selects this sample of countries.

Algeria	Brazil	Costa Rica	Poland	Tonga
Bangladesh	Cambodia	France	Syria	Zambia
Barbados	Canada	New Zealand	Tajikistan	

(a) Why might the student want to use a sample for a pilot investigation when the full data set is available?

[1]

(b) Comment briefly on how it appears this sample was selected.

[1]

Sample answer for question 6 (a) and (b)

(a) Spotting patterns may be easier with a smaller set of data.

(b) The sample takes one country from each sub region.

Commentary on the answer

(a) The answer gives a valid reason for working with a small data set.

(b) The answer correctly identifies the sampling method.

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Question 6 (c) and (d)

(c) The student uses this sample to investigate whether there is any association between the birth rate of a country and the life expectancy of its citizens.

They complete a hypothesis test using Spearman's rank correlation coefficient.

(i) Write down null and alternative hypotheses for a 2-tail test.

[1]

(ii) Complete the table to work out the test statistic.

Country	**Birth rate**	**Rank,** x	**Life expectancy**	**Rank,** y	$d=x-y$	d^2
Algeria	23.99	4	76.39	6	-2	
Bangladesh	21.61	7	70.65	10	-3	
Barbados	11.97	12	74.99	8		16
Brazil	14.72		73.28	9		0
Cambodia	24.40		63.78			
Canada	10.29		81.67		12	144
Costa Rica	16.08	8	78.23		4	16
France	12.49		81.66		9	81
New Zealand	13.40		80.93	3	7	49
Poland	9.77	14	76.65	5	9	81
Syria	22.76	6	68.41	11	-5	25
Tajikistan	24.99	2	67.06	12	-10	100
Tonga	23.55	5	75.82	7	-2	4
Zambia	42.46	1	51.83	14	-13	169

[5]

(iii) Carry out the hypothesis test using Spearman's rank correlation coefficient.

Use a 5% significance level.

[3]

(d) The student uses software to work out the product moment correlation coefficient for birth rate and life expectancy for all countries.

The result is -0.84.

Make **two** comments about this figure. **[2]**

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Sample answer for question 6 (c) and (d)

(c) (i) H_0 = There is no association between life expectancy and birth rate

H_1 = There is an association between life expectancy and birth rate

(ii)

Country	Birth rate	Rank, x	Life expectancy	Rank, y	$d=x-y$	d^2
Algeria	23.99	4	76.39	6	-2	4
Bangladesh	21.61	7	70.65	10	-3	9
Barbados	11.97	12	74.99	8	4	16
Brazil	14.72	9	73.28	9	0	0
Cambodia	24.40	3	63.78	13	-10	100
Canada	10.29	13	81.67	1	12	144
Costa Rica	16.08	8	78.23	4	4	16
France	12.49	11	81.66	2	9	81
New Zealand	13.40	10	80.93	3	7	49
Poland	9.77	14	76.65	5	9	81
Syria	22.76	6	68.41	11	-5	25
Tajikistan	24.99	2	67.06	12	-10	100
Tonga	23.55	5	75.82	7	-2	4
Zambia	42.46	1	51.83	14	-13	169
					Σd^2	798

$$r_s = 1 - \frac{6 \times 798}{14 \times (14^2 - 1)} = -0.754$$

(iii) The r_s critical value for two tailed 5% = 0.5385

-0.754 < -0.5385 so the value is significant.

So, reject H_0 and accept H_1

There is some evidence that birth rate and life expectancy are associated.

(d) The product moment result would imply that there is a strong negative correlation between the two variables.

This suggests that a high birth rate is associated with a low life expectancy.

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Commentary on the answer

(c) (i) In this answer the hypotheses are stated correctly.

(ii) The test statistic has been correctly calculated.

(iii) The correct critical value has been used; the value of the correlation coefficient has been correctly compared with the critical value. Having decided that the result is significant, the conclusion has been expressed in relation to the original context in a way which recognises that a hypothesis test can never give a definite result.

(d) The answer recognises that there is a strong negative correlation and has related this to the context.

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Summary of updates

Version (Date of issue)	Section	Change
Version 1.0 (03/2023)		
Version 2.0 (11/2025)		Our Sample Assessment Materials have been updated as part of our accessibility principles and to reflect our live assessment materials. These resources are based on the Sample Assessment Materials, so some questions have been restructured or re-worded and the candidate style responses have been revised accordingly.

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